A

Synopsis of

Proposed research work on

"Node Clustering In Wireless Sensor Network"

by

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RESEARCH TITLE:

Node clustering in Wireless Sensor Network.

RESEARCH AREA:

Wireless Sensor Network (WSN)

ABSTRACT

In recent times wireless sensor networks have grown enormously and become progressively attractive in wide variety of applications because of their low cost, low power, small in size, self-organizing behavior in harsh environments. Routing is a vital technology in WSN. There are many routing protocols like: location based, multipath, data centric, mobility based, hierarchical routing, hybrid routing etc. Clustering is used to prolong the lifetime of the wireless sensor networks. Clustering is the process where sensing area is divided in groups to balance the energy level of sensor nodes known as clusters. An Optimal Clustering technique can reduce the energy consumption in WSN and increase the lifetime of the network. Energy is the main consideration when we analyze routing protocols for WSN. Clustering sensors into groups, so that sensors communicate information only to cluster heads and then the cluster heads communicate the aggregated information to the processing center, may save energy.

Keywords- Clustering in Wireless sensor network (WSN), Cluster, Energy Efficient, Network Lifetime.

1. INTRODUCTION

1.1 WIRELESS SENSOR NETWORK

Wireless sensor networks (WSN), sometimes called wireless sensor and actuator networks (WSAN), are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location .Wireless sensors networks (WSNs), refer always to networks with limited resources, unpredictable topology and lack of infrastructure [20].Wireless sensor networks (WSNs) have received significant research focus due to their widespread applicability in military, health care, agriculture, environment monitoring applications. These applications require WSNs to be self-organized and mobile. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. Wireless Multimedia Sensor Networks (WMSNs) are comprised of small embedded audio/video motes capable of extracting the surrounding environmental information, locally processing it and then wirelessly transmitting it to sink/base station. Multimedia data such as image, audio and video is larger in volume than scalar data such as temperature, pressure and humidity. Thus to transmit multimedia information, more energy is required which reduces the lifetime of the network.

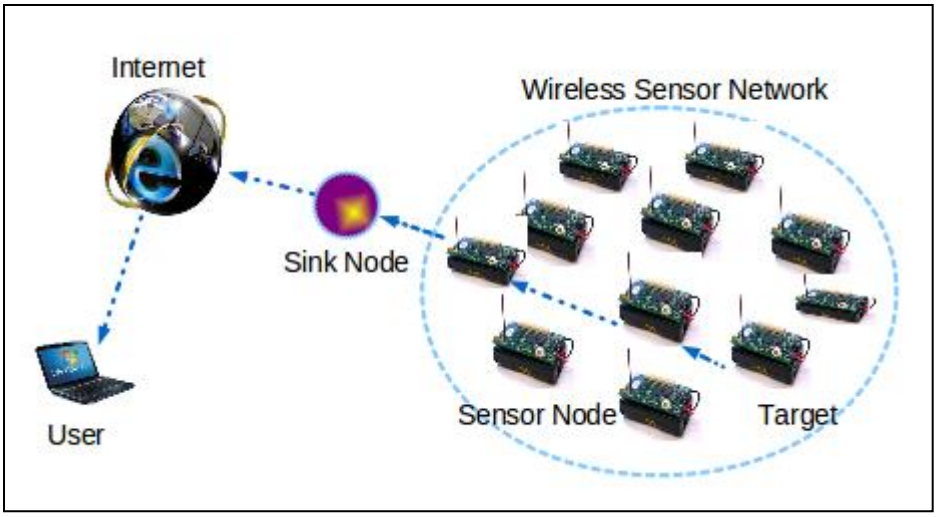

Fig.**1 Wireless Sensor Network**

Wireless sensor networks turn out to be more and more beneficial in many applications, such as ecological monitoring, smart offices, battlefield surveillance, and conveyance traffic monitoring. With the purpose of achieving high quality and fault-tolerant capability, a sensor network can be composed of hundreds or thousands of sensor nodes, which are habitually and erratically arranged inside the interested area. As there are individual nodes, there will be chances of losing connectivity of individual nodes, because WSN is usually exposed to atrocious and dynamic environments. Traditional centralized algorithms need inclusive knowledge of the whole network for operation, and if there are any problems in transmission or reception of packets to a node, chances of packet lost will occur and it will lead to a failure in protocol. Quite the reverse, distributed algorithms are performed locally inside partial nodes, thus can avoid the failure triggered by a single node. Through various observations it is stated that localized algorithms are more scalable and robust than centralized algorithms. The lifetime of WSN is limited because each sensor node is tightly power-constrained and. Hence there is a need to develop or to design energy efficient protocols for prolonging life time of a network. Efficient

arrangement of sensor nodes within clusters is beneficial in reducing energy consumption. Hence we can say clustering is an important technique to govern energy and topology as well as mobility and scalability of WSNs. There are clusters of sensor nodes in a clustered network. Every cluster has cluster head (CH), cluster member nodes (CM). Considering various clustering structure several energy-efficient routing protocols are designed. These clustering protocols smooth the load balancing and upturn the network lifetime. For example, if the energy of a cluster head (CH) becomes to be despised, another node is selected as a CH considering some threshold. In such a way, nodes in the network play a part in communication and networking responsibility by being CHs at different times. Hence, clustering enhances the network lifetime. However, the concept of clustering is still a stimulating topic in heterogeneous or distributed WSN.

1.2 CLUSTERING

Traditional routing protocols for WSN are not enough optimal in terms of energy efficiency and load balancing, Clustering is introduced to balance the load and increase the lifetime of the network. Clustering is sample of layered protocols where the network is composed of several clusters of sensor nodes. As shown in fig. 2, each cluster has a leader node which is also called as cluster head. CH takes data from all the nodes in its cluster. Cluster head aggregate all the data received from cluster members and then send that data to the base station. The transmission between cluster members and cluster head is said to be intra cluster communication, whereas the transmission between cluster head and sink is known as inter cluster communication. The local collaboration in clusters, reduce the bandwidth demands. Clustering reduce the routing overhead and make the network more stable

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). Clustering techniques are particularly important in the success of WSN implementations especially when sensor nodes are moving at different speeds. Many existing clustering algorithms assume that sensor nodes move at the same speed which is not true in many practical cases.

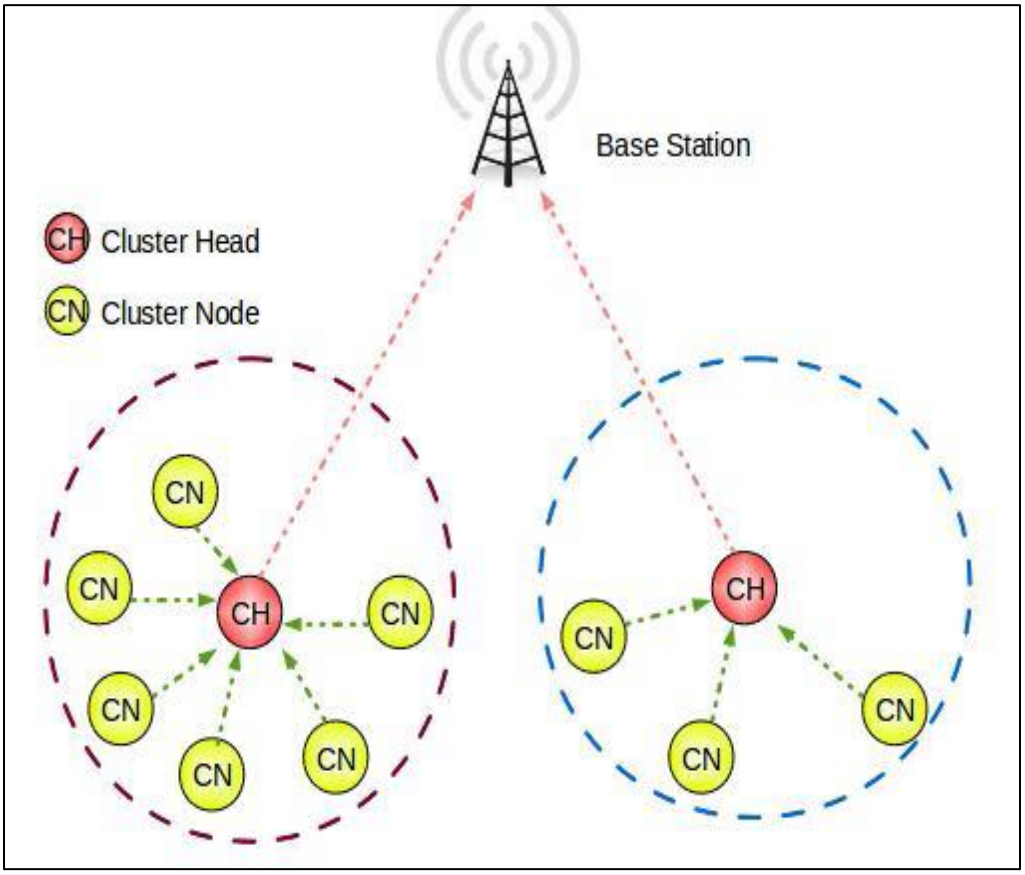

Fig. 2 Graphical Representation of Clustering

Clustering can be considered the most important unsupervised learning problem; so, as every other problem of this kind, it deals with finding a structure in a collection of unlabeled data. A loose definition of clustering could be “the process of organizing objects into groups

whose members are similar in some way". A cluster is therefore a collection of objects which are "similar" between them and are "dissimilar" to the objects belonging to other clusters.

1.2.1 ISSUES IN CLUSTERING TECHNIQUE

We have basically three issues in WSN clustering.

1. **Distance:** Distance between nodes plays a crucial role. As distance between the nodes increases the number of nodes in a cluster decreases and it may lead to higher consumption of energy.
2. **Energy:** Energy efficiency has been known as the most important issue in research of wireless sensor networks. The energy consumption within a cluster can be reduced by decreasing the number of transmitting messages. Lesser the energy consumption leads to the longer lifetime of network.
3. **Density:** The increase in sensors density may overload the network. Such overload might cause latency in communication and inadequate tracking of events.

1.2.2 CLUSTERING PARAMETERS

In WSNs clustering algorithms, it is worth reporting on some important parameters with regard to the whole clustering procedure in WSN.

1. Number of clusters (cluster count): In most recent probabilistic and randomized clustering algorithms the CH election and formation process lead naturally to variable number of clusters. In some published approaches, however, the set of CHs are predetermined and thus the number of clusters is preset. The number of clusters is usually a critical parameter with regard to the efficiency of the total routing protocol.

2. Intra-cluster communication: In some initial clustering approaches the communication between a sensor and its designated CH is assumed to be direct (one-hop communication).However, multi-hop intracluster communication is often (nowadays) required, i.e., when the communication range of the sensor nodes is limited or the number of sensor nodes is very large and the number of CHs is bounded.

3. Nodes and CH mobility: If we assume stationary sensor nodes and stationary CHs we are normally led to stable clusters with facilitated intracluster and intercluster network management. On the contrary, if the CHs or the nodes themselves are assumed to be mobile, the cluster membership for each node should dynamically change, forcing clusters to evolve over time and probably need to be continuously maintained.

4. Nodes types and roles: In some proposed network models (i.e., heterogeneous environments) the CHs are assumed to be equipped with significantly more computation and communication resources than others. In most usual network models (i.e., homogeneous environments) all nodes have the same capabilities and just a subset of the deployed sensors is designated as CHs.

5. Cluster formation methodology: In most recent approaches, when CHs are just regular sensors nodes and time efficiency is a primary design criterion, clustering is being performed in a distributed manner without coordination. In few earlier approaches a centralized (or hybrid) approach is followed; one or more coordinator nodes are used to partition the whole network off-line and control the cluster membership.

6. Cluster-head selection: The leader nodes of the clusters (CHs) in some proposed algorithms (mainly for heterogeneous environments) can be pre-assigned. In most cases however (i.e., in homogeneous environments), the CHs are picked from the deployed set of nodes either in a

probabilistic or completely random way or based on other more specific criteria (residual energy, connectivity etc).

7. Algorithm complexity: In most recent algorithms the fast termination of the executed protocol is one of the primary design goals. Thus, the time complexity or convergence rate of most cluster formation procedures proposed nowadays is constant (or just dependent on the number of CHs or the number of hops). In some earlier protocols, however, the complexity time has been allowed to depend on the total number of sensors in the network, focusing in other criteria first.

8. Multiple levels: In several published approaches the concept of a multi-level cluster hierarchy is introduced to achieve even better energy distribution and total energy consumption (instead of using only one cluster level). The improvements offered by multi-level clustering are to be further studied, especially when we have very large networks and inter-CH communication efficiency is of high importance.

1.2.3CHARACTERISTICS DESIRED IN CLUSTERS

1. Every node should be in one cluster.
2. Guarantee the total coverage of network.
3. Number of cluster head should be less so that there will be less overlapping of clusters and which will improve energy efficiency.
4. Clustering should be uniform and balanced.

1.2.4 ENERGY-EFFICIENT CLUSTERING PROTOCOLS

Sending data from source node to destination node is called routing. In routing process intermediate nodes can also collaboratively participate. The routing can be done hop by hop or end to end. In hop by hop routing the intermediate nodes are used to route the data.

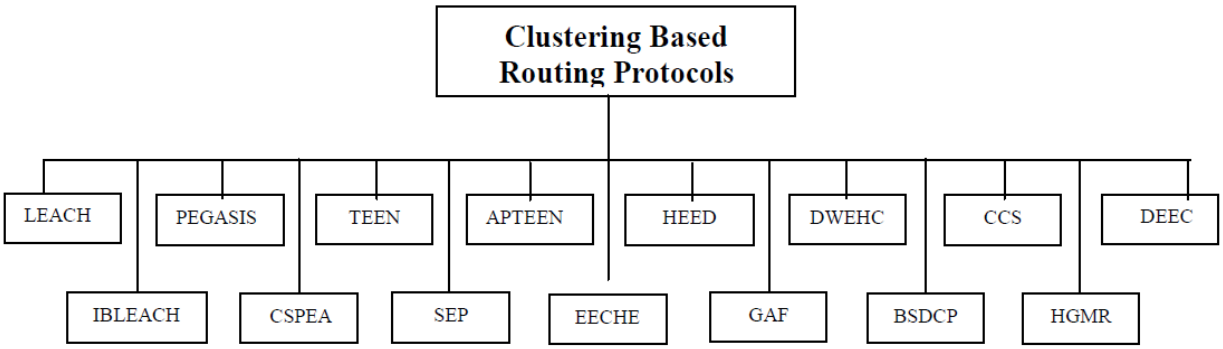

Figure 6 Clustering Based Energy Efficient Routing Protocols

Hop by hop routing is more efficient because in this technique the transmission or retransmission distance is shorter. There are mainly three types of routing: flat based routing, hierarchical based routing, adaptive routing. In flat based routing the entire sensors in the network has same role. In hierarchical based routing all nodes has different role. In adaptive routing, the role of the sensor change according to application.

2. MOTIVATION

In homogeneous WSN all the sensor nodes are equal with respect to battery energy and hardware complexity. This homogeneous WSN supports static clustering that means once the cluster heads are selected, they serve for the entire lifetime of the network. Thus, it is marked that the cluster head nodes will be over-loaded with the long range transmissions to the remote base station

(BS), and the additional processing is required for data aggregation and protocol co-ordination. As a result the cluster head nodes die before other nodes. Limitation of such homogeneous network is sensor nodes are prone to failure and does not provide any backup in case of failure of central node. Hence, to enhance the reliability of WSN and to get energy efficient WSN considering the network lifetime, a heterogeneous WSN is introduced. In a heterogeneous sensor network, considering different battery energy and functionality, two or more different types of nodes are used. Among all the sensor nodes selection of CH should be focused. The motivation being that the more difficult hardware and the additional battery energy can be implanted in few cluster head nodes, thereby sinking the hardware cost of the rest of the network. However, setting the cluster head nodes means that role rotation is no longer potent. When the sensor nodes use single hopping to reach the cluster head, the nodes that are outmost from the cluster heads continually devote more energy than the nodes that are closer to the cluster heads. Conversely, when nodes use multi-hopping to reach the cluster head, the nodes that are closest to the cluster head has the peak energy load due to relaying. Accordingly, there always exists a non-uniform energy drainage pattern in the network. Thus, to overcome the disadvantages of homogeneous and heterogeneous networks, an efficient clustering technique should be introduced. This newly introduced technique is dependent on efficient cluster head selection.

3. PROBLEM STATEMENT

To overcome limitations of the existing clustering technique, an innovative, efficient clustering protocol must be offered. The problem statement can be detailed as follows:

1) Identifying the factors that are to be considered for selection of cluster head and assistant cluster head.

2) Designing the method for prolonging the lifetime of WSN and for attaining optimum efficiency.

3) Design system for reducing the energy consumption.

4. OBJECTIVES

- Prolong the network lifetime
- Increase the security of hop by hop data routing through network
- Fast data transmission
- Reduce the energy consumption in WSN

5. LITERATURE SURVEY

An Energy-Efficient Density-based clustering technique which aims to balance the energy consumption among all clusters is proposed in [1]. This is done by the adaptation of the transmission range of cluster heads to use a suitable value according to the density around it. Simulation results for the proposed technique shows its effectiveness as it achieves less power consumption and more network lifetime when compared with other density-based clustering techniques.

Appropriate cluster head (CH) election is one such issue, which can reduce the energy consumption dramatically. Low energy adaptive clustering hierarchy (LEACH) is the most famous hierarchical routing protocol, where the CH is elected in rotation basis based on a probabilistic threshold value and only CHs are allowed to send the information to the base station (BS). But in this approach, a super-CH (SCH) is elected among the CHs who can only

send the information to the mobile BS by choosing suitable fuzzy descriptors, such as remaining battery power, mobility of BS, and centrality of the clusters. Fuzzy inference engine (Mamdani's rule) is used to elect the chance to be the SCH. The results have been derived from NS-2 simulator and show that the proposed protocol performs better than the LEACH protocol in terms of the first node dies, half node alive, better stability, and better lifetime [2].

Energy consumption of the network's nodes is considered one of the major challenges faced by researchers nowadays. On the other hand, data aggregation helps in reducing the redundant data transferred through the WSN. This fact implies that aggregation of data is considered a very crucial technique for reducing the energy consumption across the WSN. Local aggregation and Prefix filtering are two methods used [3] in which they utilize a tree based bi-level periodic data aggregation approach implemented on the source node and on the aggregator levels. Main goal is to apply data aggregation on two nodes levels. Author worked on sending fewer data from aggregator to the sink, along with the equation that expresses all data. Bayesian belief network algorithm is used to measure the accuracy of proposed method.

In [4], author explore the joint use of in-network processing techniques and clustering algorithms. This approach seeks both high data quality with a controlled number of transmissions using an aggregation function and an energy efficient network partition, respectively. The aim of this combination is to increase energy efficiency without sacrificing the data quality. They compare the performance of the Second-Order Data-Coupled Clustering (SODCC) and Compressive-Projections Principal Component Analysis (CPPCA) algorithm combination, in terms of both the energy consumption and the quality of the

data reconstruction, to other combinations of the state-of-the-art clustering algorithms and in-network processing techniques. Among all the considered cases, the SODCC + CPPCA combination revealed a perfect balance between data quality, energy expenditure, and ease of network management.

A novel scheme to secure the process of data aggregation is proposed in [5] by providing a light-weight security scheme called Combinatorial Key Distribution (CKD) mechanism that consumes less power and its performance is improved using hashes of data that is sent across the network. The proposed scheme minimizes the power usage and maximizes the secureness of data in the wireless sensor network. The proposed security scheme is compared with other existing security solutions and the results are reported.

Energy efficient clustering scheme is proposed in [6], where nodes do not transmit in full range instead have discrete power levels for transmissions. Thus transmitting nodes minimize energy wastage in transmission beyond the region of interest and avoid overhearing by most of the nodes. Intra-cluster communications are performed at lower power level and only those cluster heads are allowed to compete for cluster head selection, which have residual energy above a threshold level. We implemented this using DEEC protocol (Distributed Energy Efficient Clustering Algorithm) and called the new implementation as Modified DEEC. The proposed technique successfully conserves energy and prolongs the life time of the network in comparison to DEEC by 12.5%. There is also a substantial increase in the number of packets being transferred to base station, by a factor of 193%.

The configurations necessary for a medical based WSN with particular focus on clustering and routing is explore in [7]. It includes an implementation of a WSN architecture in Contiki operating system using Tmote Sky and open mote technologies. The underlying power consumption related to this architecture is analyzed and real world measurements are presented. Finally, the case of a modified secure routing algorithm is introduced with simulation based results showing single and collaborative selective forwarding detection/correction, and network latency. Additionally, a solution to the problem of malicious nodes dropping control messages has been provided. The uniqueness of the paper resides in the implementation of monitoring mechanism without any watchdog nodes. Moreover, to the best of the authors' knowledge, this mechanism has not been implemented on the Contiki OS.

Since sensor nodes are battery power constrained devices in wireless sensor network (WSN), so how to use the energy of sensor nodes efficiently to prolong the network lifetime is a chief challenge for designing routing protocols. To solve this problem, Author propose sleep scheduled and tree-based clustering approach routing algorithm (SSTBC) for energy-efficient in WSN in [8]. SSTBC preserves energy by turning off radio (entering sleep mode) of either impossible or unnecessary nodes, which observe almost the same information, based on their location information to remove redundant data. In addition, to further reduce energy dissipation of communication in network, build minimum spanning tree with the root as the cluster head (CH) from active nodes in a cluster to forward data packets to base station (BS).

Modified LEACH protocol for small network areas and Modified Multi hop LEACH protocol for large network areas are proposed in [9]. Simulation on LEACH, Modified LEACH

and Modified Multi-hop LEACH protocol are done. Results shows that Modified LEACH have better network lifetime than LEACH protocol.

$(LEACH)^2$: Linearly Enhanced Approach for cluster handling improving the conventional protocol LEACH (Low Energy Adaptive Clustering Hierarchy) in WSNs is proposed in [10]. The network area is divided into four regions and study the network performance in the presence of one, two and three sinks. Simulation results show that our technique with three sinks performs better than other conventional routing techniques. $(LEACH)^2$ offers increased stability period, network lifetime and throughput than LEACH.

A novel centralized clustering routing algorithm based on discrete particle swarm optimization (DPSO) is developed in [11]. The base station (BS) gathers status information from all nodes, then runs a modified DPSO algorithm to find the optimal topology for wireless sensor networks. The cluster heads election and member nodes attribution are considered as an overall problem and are optimized simultaneously. Simulation results show that the DPSO-based clustering routing has stronger ability to balance energy consumption among sensor nodes in EH-WSNs and increases the network throughput by 15% than sLEACH.

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